Sentiment analysis for Arabic tweet about the COVID-19 Worldwide Epidemic

Areej ALSHUTAYRI[1], Amal ALGHAMDI[1], Nouran NASSIBI[1], Nahla ALJOJO[2], Eman ALDHAHRI[1], Omar ABOULOLA[2]

[1] Department of Computer Science and Artificial Intelligence, College of Computer Science and Engineering University of Jeddah, Jeddah, Saudi Arabia

[2] Department of Information Systems and Technology, College of Computer Science and Engineering University of Jeddah, Jeddah, Saudi Arabia

aoalshutayri@uj.edu.sa, aalghamdi3523.stu@uj.edu.sa, nnassibi.stu@uj.edu.sa, eaal-dhahery@uj.edu.sa nmaljojo@uj.edu.sa, oaboulola@uj.edu.sa

Abstract: The purpose of this article was to highlight the sentiment analysis for specific Arabic tweets related to the COVID-19 Worldwide Epidemic. The technique proposed in this paper focused on using the machine learning algorithm with the purpose of applying sentiment analysis on a dataset which contained 4,575 Arabic tweets on the COVID-19 pandemic while also employing the Logistic Regression and Naive Bayes algorithms as classifiers for comparing the achieved results between them. This study showed the suitability and efficiency of a system using machine learning models for the analysis of Arabic tweets. The experimental outcomes revealed that the highest accuracy was reached by employing the Logistic Regression algorithm, namely, 97%. Twitter is one of the most widely used gateways of social media for the people who want to express their opinions and emotions. This study contributes to highlighting the task of sentiment analysis for the Arabic tweets about the COVID-19 pandemic by predicting the people's awareness about the Coronavirus in the Arab World.

Keywords: COVID-19, Arabic tweets, Sentiment Analysis, Machine Learning, Twitter.

1. Introduction

The great and tremendous development in all technological aspects has led to the emergence of huge sources of information and high-content data, which were the result of the increased use of the Internet at a high data transfer rate by various individuals in society.

In the beginning, the information circulating on the Internet was the preserve of governments, companies, and universities, but nowadays individuals create 71% of the Internet content (Omar et al., 2020). This included browsing or sending messages on social media networks which make up the platform of the modern world for spreading opinions, ideas, experiences, and everything that attracts attention. Consequently, social media platforms are used because they provide open spaces without limits that allow their users to express their opinions with absolute freedom.

Twitter is one of the most popular and widely used social media applications, as the number of its users has increased day by day. In view of the huge amount of information, and the opinions and points of view contained by this application, this paper focused on extracting and analyzing these opinions so that the people could benefit from them in various areas of life. By reflecting on the community's opinion on an issue, the beneficiaries of such information could make appropriate decisions. In this paper, tweets are categorized according to specific labels related to emotions (Positive, Negative, or Neutral), which helps greatly in understanding the prevailing public opinion and in making decisions and carrying out evaluations according to the analysis of these tweets and the feelings and opinions they hold (Duwairi et al., 2014).

This paper is organized as follows: Section 2 discusses the related works that have been done in the same filed and presents the results. Section 3 describes the methodology was used to build the dataset and the classification model. In section 4 the results are represented. Finally, section 5 presents the conclusion along with the future work.

https://doi.org/10.33436/v32i2y202210

2. Background and related work

A sentiment can be defined as a feeling. Sentiment analysis is a method for evaluating different references and comments in order to understand a certain brand, movement, or overarching purpose. Sentiment analysis could provide a clearer picture of peoples' emotion in social media and their reaction to certain topic which help to create an informative content analysis method. On the other hand, sentiment analysis could be seen as a group of algorithms employed in computer software which exposes and exploits views and feelings (positive, negative, and neutral) within text data in online social media resources (Duwairi et al., 2014).

From time immemorial, there was a need to establish contacts and communicate with the surrounding environment until social media networks of all kinds have reached the top spot in the current world of communications everywhere, at all times, and for everyone. In the present-day world there is a huge platform full of many ideas, emotions, and options for various social media sites, which are the most powerful sources of news, markets, industries, etc. By means of comments, tweets, ratings, reviews, and feedback it can be determined whether the feelings expressed on social media sites are negative, positive, or neutral for various fields such as marketing, industry, health, different policies, human beings, services, events and others. All of these should be analyzed and processed in order to obtain positive estimation of what the user feels and thinks (Duwairi et al., 2014). By the beginning of 2020, the world witnessed the emergence of a great pandemic, which is a new and dangerous disease, Covid-19, caused by the emerging Coronavirus. The emergence of this pandemic has been accompanied by the implementation of many measures, including preventive and awareness-raising measures, but the search for a proven treatment is still the main focus of people’s attention. The spread of this pandemic imposed many measures which can be expressed by terms such as sterilization, quarantine, healthy distancing, and many others (Wu et al., 2020).

This section discusses certain new aspects revealed by the analysis of the sentiments expressed by Arab social media users on Twitter by focusing on different Arabic dialects and emotions. The process of obtaining customer opinion was a very cumbersome task and it took a long time until automatic sentiment analysis tools became available.

Today, sentiment analysis has become easier due to the emergence of natural language processing techniques, and text analyzing. The purpose of this paper is to provide a high-precision method for sentiment analysis in the context of Arabic tweets that would not be influenced by the employment of dialects (because the Arabic language has various dialects and the meaning of certain words in each dialect is completely different, Arabic is a morphologically rich language, which causes many problems). In this respect it is found that Twitter is very well suited for the diversity of dialects in the Arab world (Omar et al., 2020; Duwairi et al., 2014).

In their state-of-art paper Duwairi et al. (2014) “Sentiment Analysis in Arabic tweets”, for this purpose 350 thousand Arabic tweets were collected, and the crowdsourcing was used to name more than 25 thousand tweets which were classified for the training data set. A dictionary of 300 words was created and the size of the data set was equal to a thousand tweets. The research focused on tools for analyzing the feelings of Arabic users of social media sites within a wide range of Apps including aspects from marketing to politics, healthcare and financial matters. They used natural language processing and morphological tool such as stemming, tokenization, and filtering unwanted words, in addition to SVM, KNN, and NB as classification algorithms. The KNN classifier reached an accuracy of 76.78%, while the SVM classifier reached an accuracy of 71.68%, and KNN showed an even lower accuracy of 59.99% (Duwairi et al., 2014).

In the paper of Baker et al. (2020) it can be found that the widespread social media platforms like Instagram, Twitter, Facebook and others, have become a basic environment for many users for sharing their opinions, joys, sorrows, and fears. Perhaps the health aspect encompassed a large share of these posts, especially with the widespread of epidemics and infectious diseases. This study dealt with one of the most serious health problems in the world, which is related to the spread of infectious diseases, specifically influenza. The research focused on analyzing feelings and knowing the opinions associated with this epidemic within the Arab region. The study focused on

collecting, analyzing, classifying, and filtering tweets in Arabic language related to influenza, and machine learning techniques and several classifiers were employed in order to carry out the required analysis, namely Naive Bayes (NB), the K-Nearest Neighbors (KNN), and Support Vector Machine (SVM). A dataset was collected from several Arab countries via twitter API, where the dataset included 54,065 with 34 keywords such as "headache" and "I am a candidate" and then the data was divided into two parts, namely valid data, and invalid data. Based on the processing techniques of coding, stop words, n-grams, and derivation, a comparison was made between the employed classifiers based on the obtained accuracy. The outcomes showed that the SVM classifier provided the lowest accuracy, whereas Naive Bayes classifier reached the highest accuracy of 89.06%, followed by the KNN classifier with an accuracy rate of 86.43% (Baker et al., 2020).

The paper of Muthusami et al. (2020) discussed and analyzed the tweets related to the emerging Coronavirus disease. The focus of this analysis was on finding out the very positive and very negative feelings and opinions of various people around the world related to the Covid-19 pandemic. An algorithmic approach was implemented for collecting data from 18,216 tweets via Twitter API and Google TAGS. The analysis employed supervised machine learning with Naive Bayes classifiers as well as an approach based on many known sentiment classification methodologies. LogitBoost approach is used, which is a blended approach and also an opinion lexicon was used for processing the collected data, for the creation and selection of features. And an evaluation of the classifier is performed based on hashtags such as #covid-19. The sentiment scores are derived by knowing whether the messages are negative or positive, with regard to the Coronavirus disease in aspects related to media, health, education, food, money and others. The results showed that the LogitBoost approach, which is a blended approach and was created by comparing several known sentiment classification methodologies, has proven its superiority over the NB machine learning approach by reaching an accuracy of 74%, while NB reached an accuracy of 72% (Muthusami et al., 2020).

The Coronavirus disease has imposed many developments, restrictions, and procedures that changed many aspects of the peoples' lives, and was accompanied by many negative emotions, which largely outnumbered the positive ones. Samuel et al. (2020) focused on analyzing the feelings of fear and panic accompanying the Coronavirus disease in the world. This research was carried out in order to find out the public sentiments associated with the massive invasion of the Coronavirus by adopting the Twitter platform to collect data and information from the 53,127 selected Twitter tweets and then commented sentiment analysis on the required text. After that, the evaluation was based on sentiment label and textual analysis using two classifiers namely, the Naive Bayes (NB) algorithm and the Logistic Regression (LR) algorithm which accurately predicts the sentiments expressed on Twitter. Finally, the evaluation and comparison of the employed methodologies were carried out, and the results concluded that NB outperformed LR with regard to short tweets. NB obtained an accuracy of 91.43%, while LR reached a somewhat acceptable accuracy of 74.29%. In the case of long tweets, it can be noted that both methods reached a relatively low accuracy in comparison with the results obtained for short tweets, namely the accuracy of NB for long tweets reached 57.14% and the accuracy of LR reached 52% (Samuel et al., 2020).

The paper of Chakraborty et al. (2020) proved the surprising fact that although people were initially accessing neutral and positive information, many users were re-tweeting the tweets which conveyed negative information. This study focuses on the eagerness of using "monitoring mechanism" in order to avoid negative feelings and opinions from being disseminated within the brains of social media users. The dataset including 226,668 tweets and the achieved accuracy using Gaussian membership function based fuzzy rule up to 79%. The model proposed by this paper relied on fuzzy logic which is implemented by Support Vector Machine (SVM), and the accuracy of the deep learning classifier reached to 81% (Chakraborty et al., 2020).

According to the above summary of the related work, the aim of the current paper was to use Naïve Bayes and logistic regression for classifying the selected tweets because they reached a high accuracy.

Table 1 compares the different studies presented as related work.

Table 1. Summary of related work.

The title of the selected paper	Year	Source	Size	Classifier	Accuracy
Sentiment Analysis in Arabic tweets	2014	Twitter	1000	SVM	71.68%
				KNN	76.78%
				NB	59.99%
Detecting Epidemic Diseases Using Sentiment Analysis of Arabic Tweets	2020	Twitter	54,065	NB	89.06%
				KNN	86.43%
COVID-19 Outbreak: Tweet based Analysis and Visualization towards the Influence of Coronavirus in the World	2020	Twitter	18,216	NB	72%
				LogitBoost	74%
COVID-19 Public Sentiment Insights and Machine Learning for Tweets Classification	2020	Twitter	53,127	NB LR	for short tweets (NB)91.43% (LR)74.29%
				NB LR	for long tweets (NB)57.14% (LR)52%
Sentiment Analysis of COVID-19 tweets by Deep Learning Classifiers—A study to show how popularity is affecting accuracy in social media	2020	Twitter	226,668	SVM	79%
				Deep learning classifier	81%

3. Methodology

In order to build a corpus for sentiment analysis of Arabic tweets about the COVID-19 pandemic, certain main steps should be followed. First, the tweet data that will be processed was collected from Twitter. Then, data cleaning was performed, along with the normalization of certain Arabic letters and Arabic word stemming in order to prepare the selected corpus for labeling. After that, the experiment was carried on by extracting the features that all tweets contain which are considered as main keywords about COVID-19 to be used in the training set sentiment classifiers were applied on the given dataset. Finally, the classifiers were validated by using a cross-validation approach. Each step of the experiment is shown in Figure 1 that illustrates the proposed model for implementing a sentiment analysis for Arabic tweets on the COVID-19 pandemic by using Twitter data.

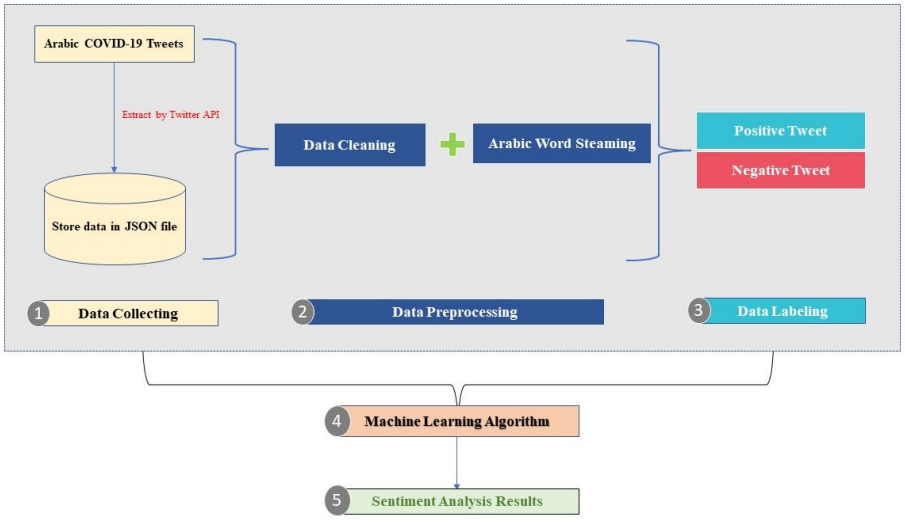

Figure 1. The proposed model for implementing a sentiment analysis of Arabic tweets on the COVID-19 pandemic

3.1. Data collecting and preparation

Based on the first step illustrated in Figure 1, the dataset presented in (Gimpel et al., 2011) was used, which contains about 70 keywords related to the Coronavirus pandemic and the accompanying health consequences, clinical manifestations, behaviors, quarantine, social distance, and others. The dataset contains around 3.8 million Arabic tweets about the Coronavirus from 1-Jan-2020 until 10-April-2020. In this paper, after extracting the whole dataset, only one month was chosen, that is March 2020 with 8 keywords most related to the COVID-19 pandemic, namely:

- K1= 'كورونا'
- K2 = 'كرونا'
- K3 = 'كوفيد'
- K4 = 'كوفيد١٩'
- K5 = 'فايروس كورونا'
- K6 = 'فايروس كرونا'
- K7 = 'covid19'
- K8 = 'covid'

After that the size of the dataset was reduced to 4,575 Arabic tweets. Table 2 illustrates the details of collected data with certain samples of tweets. ID profiles were obtained that serve the field of study in focus. Then, the hydrator program located on GitHub was downloaded, which can be used for extracting tweets by using IDs files. After that, we have linked with the different Twitter accounts based on the selecting IDs, now the selected id gives the full object which consists of the tweet and all related information such as ID, location and so on. and on this basis by extracting the whole tweets and related information, we have relied on the dataset. Finally, JSON files were used for storing datasets due to their being more suitable for the Arabic language and the related content problems with coding.

Table 2. Examples of collected data before preprocessing

Keywords	Examples (Arabic)
كورونا	😂😂😂😂😂 شوكلاته كورونا الزرقا ب7.5 قرش https://t.co/316jCo69cZ Translation: Corona blue chocolate for 7.5 piasters
	RT @BinWaayal: هل تعلمون كان يروج للمخاوف من كورونا ويكبر الموضوع بتقارير كاذبة؟ https://t.co/24swYSyGXk Translation: Do you know he was promoting fears of Corona and exaggerating the issue with false reports?
كوفيد-19	Jeddah field hospital ابطال كوفيد-١٩ فصيلتي حملات التبرع بالدم Translation: Covid-19 Champions , Blood donation campaigns, my group
فايروس كورونا	@m__h300 @nawaf_nfbh11 @BBCArabic نعم من هنا انتشر فايروس كورونا؟؟ Translation: Yes, from here the Coronavirus spread ??

3.2. Data preprocessing

As it is illustrated in Figure 1, the raw tweets need to pass through certain preprocessing steps for clearing the noises and the unwanted data in order to prepare them for the sentiment analysis. The data preprocessing step was divided into two phases. In phase 1, the dataset was

cleaned by using Ark Tweet NLP library which was especially designed to handle Twitter messages and texts by a team of researchers from Carnegie Mellon University (Kolchyna et al., 2015). Data cleaning was performed, such as removing hashtags (#hashtag_name), user mentions (@username), URLs (http:// and https://), whitespaces (any extra space or new lines), and retweets (including RT), and punctuation such as (!@#$%^&*()_+<>?:.;؟-}{،؛) was removed. Next, in phase 2, Arabic word steaming was carried out by replacing text words with their roots. The effectiveness and total impact of a derivation depends mainly on two factors: the first factor is the data set, and the second factor is the derivation algorithm. It should be noted that the derivation may reduce the accuracy of sentiment analysis, and the derivation process is often avoided in the final implementation of the sentiment analysis algorithm in order to raise the accuracy of the algorithm and achieve the required level for it (Zhang & Lee, 2003).

3.3. Data labeling

In this step, as it is illustrated in the proposed model in Figure 1, the paper discusses the corpus labeling that was used for developing a tagged corpus for sentiment analysis. To classify each tweet according to polarity, two tags were used: positive, and negative. Furthermore, in this step a code was written for labeling each tweet in the dataset, if a tweet contained one of the 8 keywords mentioned before like (كوفيد") ("كورونا") it would be positive, otherwise it could be classified as a negative tweet. Table 3 illustrates some examples of tweets with labeled tags.

Table 3. Some examples of tweets with labelled tags

Tags	Examples
Positive	حجر فني ، وروني ايش فعالياتكم بالحجر ؟حجر صحي حجر السعادة كورونا اجلس بالبيت Translation: An artistic quarantine, show me. What are your activities during the quarantine? Quarantine, a happiness quarantine, Corona. Stay at home.
Negative	نعمل كـ كوادر طبية أمنية ليل نهار لحماية المواطن والوطن . أجلس بالبيت Translation: We work as medical security staff day and night to protect the citizen and the homeland. “Stay at home”.
Positive	ثوينيات في الأزمات يتضح الرجال ففي ازمة كورونا وقفت الدولة السعودية مع المواطن والمقيم مالم تفعله الدول المتقدمة Translation: In crisis, men become clear. In the Corona crisis, the Saudi state stood by the citizen and resident, unless developed countries do
Positive	من أجل صحتك وصحة الآخرين وحفاظًا على جهود الدولة و حتى لا تهدرها ابق في بيتك .اجلس بالبيت كلنا مسؤول كورونا Translation: For the sake of your health and the health of others, and in order to preserve the efforts of the state and not to waste them, stay at home. We are all responsible for Corona.

4. Experimental results

Machine learning is an important filed in Artificial Intelligence which is used for analyzing huge amount of data (Popescu & Ichimescu, 2021). This section discusses the validation of the employed classifiers as it was mentioned in Figure 1. To evaluate the performance of the proposed system, the dataset related to of the Arabic tweet corpus was split into a training and a testing

dataset. Cross-validation was used namely the dataset was split into 80% for training and 20% for testing. In this paper, two different types of classifiers were used, that is the Logistic Regression (LR) and Naive Bayes (NB) algorithms. The Logistic Regression (LR) classifier performed better than the Naive Bayes (NB) classifier and proved to be the best for classifying the sentiment expressed by the selected Arabic tweets. The algorithm reached at the end of the experiment an accuracy of 97%, which is good accuracy as it allows an accurate and appropriate classification. Table 4 shows the comparative results for the LR and NB classifiers with regard to accuracy.

Table 4. Compression between the LR and NB classifiers in terms of accuracy

The employed classifier	**Accuracy**
Logistic Regression (LR)	97%
Naive Bayes (NB)	75%

Figure 2 shows the contrast by category labels that were used in the dataset which are Positive =1 and Negative =2.

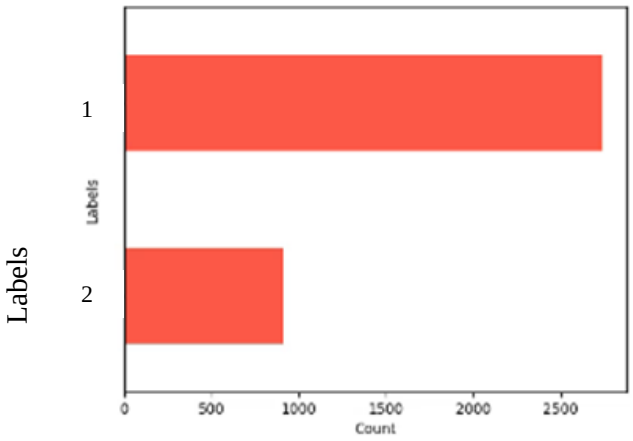

Figure 2. Contrast by category of labelling

Figure 3 below shows the confusion matrix which was used for evaluating the performance of the proposed model. As it is shown in Figure 3, the confusion matrix consists of true or actual labels and predicted labels which were obtained by using the Logistic Regression classifier, that is True Negative TN when the tweet is negative and predicated as negative, True Positive TP when the tweet is positive and predicated as positive, False Negative FN when the tweet is positive but predicated as negative, and False Positive FP when the tweet is negative but predicated as positive.

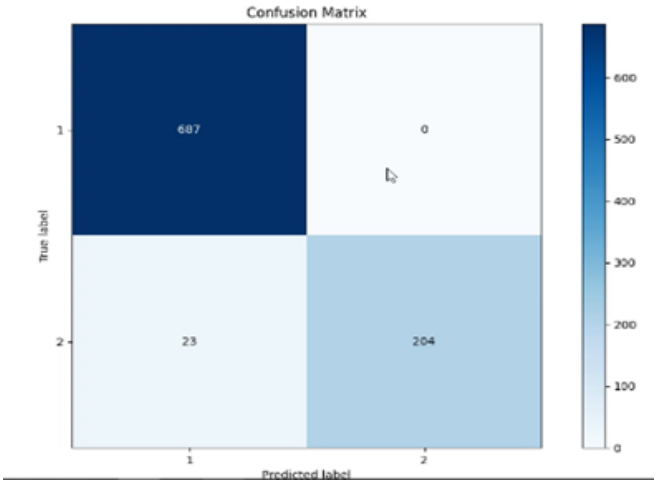

Figure 3. Confusion Matrix

Table 5 shows the results obtained after implementing the training and prediction process in the context of employing several performance measures, namely: precision, recall, F1-score, and support.

Precision indicates the number of times when the classifier predicted wrong labels.

Precision = TP/(TP + FP)

Recall presents the ratio of correctly predicted labels to all the tweets in a given class.

Recall = TP/(TP+FN)

F1-score determines the mean of precision and recall (MSADAA & Grayaa, 2022).

F1 Score = 2*(Recall * Precision) / (Recall + Precision)

Support is defined as the numbers of occurrences for each class in the category of labels which were predicated as true.

According to the results shown in Table 5 for the classification report of logistic regression classifier, precision shows high results with percent reach 1 in positive label. The recall, too, has reached the value 1 for the negative label. F1-score gave results very close to 1, which indicates that the proposed model performed a good classification job.

Table 5. The results obtained after implementing the training and prediction process for four performance measures: Precision, Recall, F1-score, and Support

	Precision	**Recall**	**F1-score**	**Support**
Negative label	0.954483	1.000	0.97671	692.00
Positive label	1.000	0.85135	0.91970	222.00
Macro average	0.977241	0.92567	0.94821	914.00
Weighted average	0.965538	0.96389	0.96286	914.00

5. Conclusion

This paper highlights the importance of sentiment analysis especially for Arabic tweets that address the COVID-19 pandemic. In this paper, sentiment analysis was applied on a dataset which contained 4,575 Arabic tweets of the COVID-19 pandemic. The proposed technique focused on employing Logistic Regression and Naive Bayes as classifiers in order to compare the achieved result between them. Interestingly, the experimental findings showed that the most precisely results (an accuracy of about 97%) can be reached by using the Logistic Regression algorithm. As future work, deep learning algorithms could be employed with the purpose of comparing their performance with that of the machine learning algorithms. Moreover, in this paper, the chosen dataset was classified according to only two labels (negative and positive). In this sense, in the future the aim is to add new labels for classifying the selected tweets and apply the proposed technique on a larger dataset.

REFERENCES

1. Baker, Q. B., Shatnawi, F., Rawashdeh, S., Al-Smadi, M. & Jararweh, Y. (2020). *Detecting Epidemic Diseases Using Sentiment Analysis of Arabic Tweets*. Journal of Universal Computer Science, 26(1), 50-70.
2. Chakraborty, K., Bhatia, S., Bhattacharyya, S., Platos, J., Bag, R. & Hassanien, A. E. (2020). *Sentiment Analysis of COVID-19 tweets by Deep Learning Classifiers - A study to show how popularity is affecting accuracy in social media*. Applied Soft Computing, 97 (Part A), 106754.

3. Duwairi, R. M., Marji, R., Sha'ban, N. & Rushaidat, S. (2014). *Sentiment Analysis in Arabic tweets.* Conference: 2014 5th International Conference on Information and Communication Systems (ICICS), pp. 1-6.
4. Gimpel, K., Schneider, N., O'Connor, B.T., Das, D., Mills, D., Eisenstein, J., Heilman, M., Yogatama, D., Flanigan, J. & Smith, N.A. (2011). *Part-of-speech tagging for twitter: Annotation, features, and experiments*. In Proceedings of the 49th Annual Meeting of the Association for Computational Linguistics, pp. 42-47. Portland, Oregon: Association for Computational Linguistics.
5. Kolchyna, O., Souza, T. T., Treleaven, P. & Aste, T. (2015). *Methodology for Twitter Sentiment Analysis*. arXiv.
6. Msadaa, I. C. & Grayaa, K. (2022). *Covid-19 detection: a Deep Learning Approach based on Wavelet Transform*. Revista Română de Informatică și Automatică (Romanian Journal of Information Technology and Automatic Control), 32(1), 87-98.
7. Muthusami, R., Bharathi, A. & Saritha, K. (2020). *COVID-19 Outbreak: Tweet based Analysis and Visualization towards the Influence of Coronavirus in the World*. Gedrag & Organisatie Review, 33(2), 534-549.
8. Omar, Y. A., Al-Tawil, M., Huneiti, A. M, Shahin, R. A., Zayed, A. A. & Al-Dibsi, R. H. (2020). *Twitter Sentiment Analysis Approaches: A Survey*. International Journal of Emerging Technologies in Learning (IJET), 15(15), 79-93.
9. Popescu, F. & Ichimescu, C. (2021). *Construcția, instruirea și validarea unui sistem de avertizare timpurie asistat de inteligență artificială pentru gestionarea pandemiei COVID-19*. Revista Română de Informatică și Automatică (Romanian Journal of Information Technology and Automatic Control), 31(2), 7-20.
10. Samuel, J., Ali, G. G., Rahman, M. M., Esawi, E. & Samuel, Y. (2020*). COVID-19 Public Sentiment Insights and Machine Learning for Tweets Classification*. Information, 11(6), 314.
11. Zhang, D. & Lee, W.S. (2003). *Question classification using support vector machines*. In the Proceedings of the 26th annual international ACM SIGIR conference on Research and development in informaion retrieval, pp. 26–32.

* * *

Areej ALSHUTAYRI is an Assistant Professor in the department of computer science and Artificial Intelligence at the University of Jeddah. Areej collected and created a social media Arabic dialect text corpus (SMADC) using Twitter, Facebook, and Online newspapers. Areej's research interests in using Artificial Intelligence which include machine learning and natural language processing to understand languages especially Arabic language and its dialects.

* * *

Amal ALGHAMDI is a master's student at College of Computer science and Engineering, Computer Science and AI Department, University of Jeddah, Jeddah, Saudi Arabia.

* * *

Nouran NASSIBI is a master's student at College of Computer science and Engineering, Computer Science and AI Department, University of Jeddah, Jeddah, Saudi Arabia.

* * *

Nahla ALJOJO obtained her PhD in Computing at Portsmouth University. She is currently working as an Associate Professor at College of Computer Science and Engineering, Information system and information Technology Department, University of Jeddah, Jeddah, Saudi Arabia. Her research interests include: adaptivity in web-based educational systems, e-Business, leadership's studies, information security and data integrity, e-Learning, education, AI , Machine Learning, Deep Learning , health informatics, environment and ecology, and logistics and supply chain management. Her contributions have been published in prestigious peer-reviewed journals.

* * *

Eman ALDHAHRI received her Ph.D. degree in Computer Science from University of Memphis, Memphis, United States of America in 2019. She received her M.Sc. degree in Computer Science from Southern Illinois University, Carbondale, United States of America in 2014, and her B.Sc. Degree in Computer Science from Taibah University, Al-madinah, Saudi Arabia in 2006. Dr. Aldhahri is currently an assistant professor at the Computer Science and AI department, in the College of Computer Science and Engineering, at the University of Jeddah, Jeddah, Saudi Arabia.

* * *

Omar ABOULOLA received his Doctorate degree from IST, CISAT, Claremont Graduate University , Claremont, United States of America. Dr. Omer is currently an assistant professor at the Information and Technology department, in the College of Computer Science and Engineering, at the University of Jeddah, Jeddah, Saudi Arabia. His research interests include: GIS, Persuasive Technology, Design Science Research, and Human Computer Interaction